PNAS RESEARCH ARTICLE | ANTHROPOLOGY

A new chronology for the Māori settlement of Aotearoa (NZ) and the potential role of climate change in demographic developments

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Edited by Patrick Kirch, University of Hawaii at Manoa, Berkeley, CA; received May 4, 2022; accepted September 23, 2022

Understanding the role of climate change, resource availability, and population growth in human mobility remains critically important in anthropology. Researching linkages between climate and demographic changes during the short settlement history of Aotearoa (New Zealand) requires temporal precision equivalent to the period of a single generation. However, current modeling approaches frequently use small terrestrial radiocarbon datasets, a practice that obscures past Māori population patterns and their connection to changing climate. Our systematic analysis of terrestrial and marine ^{14}C ages has enabled robust assessments of the largest dataset yet collated from island contexts. This analysis has been made possible by the recent development of a temporal marine correction for southern Pacific waters, and our findings show the shortcomings of previous models.We demonstrate that human settlement in the mid to late 13th century AD is unambiguous. We highlight initial (AD 1250 to 1275) settlement in the North Island. The South Island was reached a decade later (AD 1280 to 1295), where the hunting of giant flightless moa commenced (AD 1300 to 1415), and the population grew rapidly. Population growth leveled off around AD 1340 and declined between AD 1380 and 1420, synchronous with the onset of the Little Ice Age and moa loss as an essential food source. The population continued to grow in the more economically stable north, where conditions for horticulture were optimal. The enhanced precision of this research afforded by the robust analysis of marine dates opens up unique opportunities to investigate interconnectivity in Polynesia and inform the patterns seen in other island contexts.

Polynesian settlement | marine ^{14}C reservoir | Māori archaeology | Little Ice Age | empirical analysis

Significance

For decades, the initial human settlement of New Zealand (NZ) has been estimated to have occurred between the 12th and 14th centuries AD. Our modeling of a large terrestrial and marine radiocarbon dataset resulted in a new high-resolution chronology of Māori settlement and demography beginning in the mid-13th century AD. We show for the first time a measurable temporal difference between initial human settlement across the north and south islands supported by the fluctuating population, deforestation, and subsistence trends. This finding indicates that Māori adapted quickly to a large, diverse environment and dynamic temperature and precipitation patterns. This work heralds a new phase of chronometric contribution to understanding past cultural behavior.

Oceanographic conditions between AD 700 and 1350 (approximately the Medieval Warm Period) enabled people to expand and settle subtropical and sub-Antarctic islands across East Polynesia, including Aotearoa (New Zealand [NZ]), one of the last landmasses inhabited by people. Located at the fringe of East Polynesia and outside the tropical zone, the temperate climate of NZ was less familiar to early Polynesian settlers (1). In addition, the latitudinal range and varied topography of NZ provided economic opportunities requiring the adaptation of extant skills. At this time, the South Island (SI) had substantial colonies of large wingless ratite birds (Dinornithiformes), moa, which became rapidly extinct within 1 or 2 centuries after human contact (2, 3). The primary drivers of this abrupt extinction event have been attributed to combined demographic and environmental pressure caused by overhunting and the fragmentation and loss of habitat (see, for example, ref. 4). Moreover, the extirpation of moa, coupled with less stable weather conditions starting at AD ∼1350 to 1400 (the Little Ice Age [LIA]) (5–9), may have resulted in early Māori population fluctuations, mobility, and changes in food production and consumption patterns. Specifically, a return to dietary staples initiated the spread of horticulture in the warmer North Island (NI) and increased reliance on marine protein (10).

The timing of Polynesian settlement and subsequent demographic developments remains contested and has yielded broad 12th to 14th century dates (2, 11, 12). Recently, Walter et al. (1, pp. 355) argued that "the sudden and widespread appearance of sites in the 14th century is the result of mass migration and the adoption of a particular set of colonization strategies; it is not the outcome of demographic growth out of a currently invisible earlier population base." Archaeological data in support of this statement is limited to the observation that "sites containing both moa bone as food remains and artifacts of tropical East Polynesian form date no earlier than the first decades of the 14th century AD and in decline by the beginning of the 15th" (1, pp. 354). Other scholars have used the deposition of a volcanic ash isochron, the Kaharoa tephra, dated to AD 1314 ± 6 y (13), as a *terminus post quem* date in support

Author contributions: M.M.E.B. and F.P. contributed to the conception and design of the study and data collection; M.M.E.B. performed research. M.M.E.B. and S.H.B. analyzed the data; M.M.E.B. and F.P produced the figures; M.M.E.B. wrote the initial draft of the manuscript; and M.M.E.B. and F.P. reviewed and edited the manuscript.

The authors declare no competing interests.

This article is a PNAS Direct Submission.

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This article contains supporting information online at http://www.pnas.org/lookup/suppl/doi:10.1073/pnas.2207609119/-/DCSupplemental

Published November 7, 2022.

of an AD 14th century date of settlement. The presence of a single seed gnawed by introduced commensal, the Pacific rat (kiore or *Rattus exulans*), found within this tephra layer, has been used as evidence that people had been on the NI by the time of the volcanic eruption (11). However, identifying *in situ* tephra isochrons either within or immediately below any archaeological site in the northeast NI of NZ limits the use of this isochron.

In contrast to a mass migration event, Anderson (14) has portrayed the overall Polynesian settlement of NZ as nearly continuous and identifies three phases of cultural and demographic change. He describes the "Archaic East Polynesian" phase (AD ∼1250 to 1450) as typified by a small and evenly spread population that settled in sheltered coastal locations and adapted to moa hunting. Groube (15) and Kirch (16) earlier suggested a small founding population that underwent rapid demographic growth, a conclusion supported by subsequent DNA research (17). Following this initial settlement phase, in the "transitional" or "proto-Māori" phase (AD ∼1450 to 1650) exponential population growth, movement inland, the development of horticulture, and the appearance of fortified settlements (pā) across the landscape occurred (18). In the "Classic Māori" phase (AD ∼1650 to 1800) a shift in population to the NI occurred, with an increased reliance on the horticulture (14). However, this three-tiered structure provides few links with the traditionally recorded events that shaped Māori culture and tells us little about environmental adaptation, socioeconomic developments, material culture changes, or human behavior.

Finding archaeological evidence of Polynesian settlement and documenting changes in Māori culture are complicated by archaeological site integrity and visibility, few diagnostic artifacts, and imprecise chronometric control over these events. Moreover, persistent problems with modeled chronologies have occurred because of the biased analysis of ^{14}C dates. Recent efforts in statistical modeling have focused on specific questions relating to the demise of moa (2, 4, 19), the appearance of *Rattus exulans* (2, 20), or the timing of an early settlement site at Wairau Bar in the SI (21). Demographic developments have been reconstructed using summed anthropogenic ^{14}C dates as a proxy for past population trends (22). This approach assumes that the larger the population, the richer the cultural deposits (hence, more midden layers, pits, horticultural activities, among others) and the more radiocarbon measurements obtained on the archaeological remains (23). The significance of this method is that researchers can compare population fluctuations to other archaeological and environmental trends. Nevertheless, scholars have recognized biases affecting the proxies (see *Materials and Methods*), and most recommend using large and qualitative sample sizes to overcome biases (24). The current models for NZ, however, rely on statistically small datasets composed of terrestrial ^{14}C ages with little comparison to traditional archaeological proxies, such as the number of archaeological sites.

In the last decade, the NZ ^{14}C dataset has increased sixfold. We use 2,254 terrestrial and marine ^{14}C ages, more than half of which are marine shells, compared to 334 to 481 terrestrial dates in earlier studies (11, 22). The recent development of a calibration curve that accounts for temporal change in the regional marine reservoir (7) allows for the integration of marine samples in Bayesian and population models, enabling the analysis of the largest ^{14}C dataset from an island context in the Pacific. This extensive dataset facilitates a more precise empirical assessment of the timing, rate, and scale of initial settlement for the first 250 y of the history of NZ (AD 1250 to 1500). However, initial assessments required a comprehensive ^{14}C data quality assessment, resulting in the exclusion of 696 samples with problems in the metadata (25), as described in the *SI Appendix*.

The contributions of the present paper are threefold: First, using 1,558 reliable ^{14}C dates, we apply a qualitative Bayesian approach to model the highest probability distributions (HPDs) of the regional events (26). Second, using quantitative methods, we use two archaeological proxies to estimate activity intensities as a proxy of population size: summed probability distributions (SPDs) of ^{14}C dates (27) and raw counts of archaeological sites in 50-y intervals and their spatial distribution (this paper). Third, we discuss the potential role of climate constraints in shaping demographic trends, including voyaging feasibilities, deforestation, and horticulture practices. Such relationships provide insight into how Māori society built resilience to a diverse ecosystem and changing temperate climate at the fringe of the Southern Pacific Ocean. Moreover, it is now possible to interrogate adaptations made by people, changes in the environment, and resource availability. By studying these potential connections, we can make more informed decisions about our impact on island ecosystems.

Results

In the NI, 941 reliable ^{14}C dates come from 436 archaeological sites, and in the SI, 617 dates come from 145 locations. Although 75% of all sites are located in the NI, the SI averages 50% more ^{14}C ages per site, which may introduce statistical bias. Fifteen percent of the dataset consists of short-lived terrestrial materials (TSLs), 52% are marine samples (MSs), and 33% are terrestrial charcoal samples with inbuilt age (TIAs).

We undertook a series of tests investigating the precision and accuracy of Bayesian HPDs and population SPDs (*SI Appendix*, Fig. S3 and Tables S2 and S3). Differences in the NI and SI datasets and marine calibration curves are both portrayed in HPDs and SPDs. Results using the South Pacific marine calibration curve align well with the HPD and SPD for calibrated terrestrial dates, and this marine curve is used throughout this paper (Fig. 1*B* and *SI Appendix*, Fig. S3*B*). Overall, we find that robust HPDs of island-wide scales should include at least 90 unordered ^{14}C ages in single-phase models. SPDs should have at least 200 ^{14}C ages (24), ideally consisting of a variety of TSL, MS, and TIA dates to account for both sample numbers and uniform distributions (Fig. 1 *A*–*C* and *SI Appendix*, Fig. S3 *D*–*H*). Schmid et al. (25, 28) previously demonstrated, using independently dated tephra events, that a large and diverse dataset results in greater accuracy for archaeological events.

The Timing of Polynesian Arrival in NZ. Statistical models that include reliable TSL and MS or TSL, MS, and TIA ^{14}C ages result in a mid- to late 13th century arrival date. Moreover, settlement occurred a decade earlier in the NI (HPD of AD 1250 to 1275) than in the SI (HPD of AD 1280 to 1295) (Fig. 1*C*). Specific material types, however, return varying dates for the onset of activities.

Moa hunting activities, as indicated by moa eggshell dates or combined moa eggshell and bone dates, commenced in AD 1300 to 1320 (Fig. 1*A*). Our evaluation shows that moa hunting continued for ∼100 y before it stopped around AD 1400 to 1415. Three ^{14}C ages fall outside the hunting period, the earliest dating to AD 1275 to 1295 (NZA-52932) and the youngest to AD 1415 to 1460 (NZA-52929 and Wk-12962), respectively. The eggshell dataset (n = 115) primarily derives from 13 sites spread across the SI; one date comes from the NI

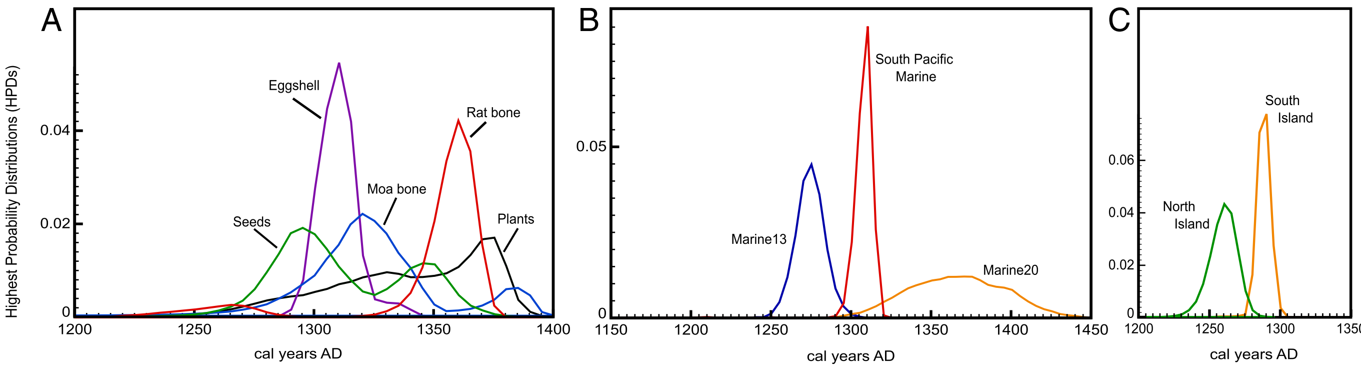

Fig. 1. HPDs for archaeological events. Colored lines as described in each figure. (*A*) TSL samples. Eggshell (n = 115) and moa bone (n = 7) represent moa-hunting activities, while rat bone (n = 25) and rat-gnawed seeds (n = 24) represent the spread of rats. TSL materials can underestimate early settlement activities. (*B*) MS dates (n = 141) were modeled using three global and regional calibration curves (Marine[13], Marine[20], "South Pacific"). The South Pacific curve agrees with calibrated results from terrestrial samples and is used in all subsequent models. (*C*) TSL and MS datasets represent the human settlement of NZ. The NI (n = 91) was reached before the SI (n = 245). Approximately 90 ^{14}C dates provide robust estimates of island settlement. Cal, calendar.

(AD 1280 to 1390; NZ-1725), which indicates a difference in the availability of moa in this region. Our model suggests that large-scale moa hunting in the SI became a significant economic determinator within 25 to 75 y of initial settlement in the NI and was not associated with the earliest settlement. While our model estimates the decline in moa hunting, the extinction of moa has been previously modeled to AD 1427 to 1461 and AD 1450, respectively (2, 3).

The problem with dating a specific material category associated with an event is also evident in the *R. exulans* ^{14}C dates distribution. *R. exulans* would have become visible in the archaeological record following their introduction by Polynesian settlers (29). Rats (22 rat bones and 2 rat-gnawed seeds from 4 sites) appear first in the NI at AD 1245 to 1285, then in the SI from AD 1365 to 1420 (9 rat bones and 22 rat-gnawed seeds from 7 sites) (*SI Appendix*, Table S2*C*). Rats arrived in the NI 35 to 70 y before the Kaharoa tephra fell in AD 1314 ± 6 y. However, rat bone dates have a troubled history of reliability (20), and both rat bone and the rat-gnawed seed ^{14}C datasets are small. Moreover, many rat-gnawed seeds are not directly associated with human activity. Although the rat population would have exploded on arrival, these dates do not necessarily represent the earliest human settlement in these areas.

Early Māori Demographic Developments. The modeled trend for the NI ("unbinned" and "binned" SPDs) indicates a gradual population increase between AD 1250 and 1450 (Fig. 2*A*). The population significantly increased between AD 1350 and 1450, and the numbers maintain after that date. The archaeological site frequencies indicate a minor decrease after AD 1300 and an exponential increase after AD 1400 (Fig. 2*B*). Population trends in the SI follow a different pattern. The binned SPD shows an increase in population from AD 1280 until AD 1340, followed by a minor decrease between AD 1380 and circa AD 1420, after which population numbers stagnate (Fig. 2*A*). However, this early population peak is much more dramatic when ^{14}C dates are unbinned, a finding supported by the frequency of archaeological sites relative to ^{14}C ages (Fig. 2*B*). The apparent high population peak, therefore, reflects different sampling intensities, in which early settlement contexts have been oversampled (e.g., *SI Appendix*, Table S4). Binned SPDs align well with raw counts of archaeological sites and the spatial distribution of ^{14}C dates in both island settings (Fig. 3). Consequently, our analysis refutes a 14th century mass migration event (see, for example, ref. 4). It also highlights that the eastern NI volcanic eruption that produced the Kaharoa tephra would have had little impact on most of the population, which had dispersed to the SI by this time (Fig. 3).

Discussion

A qualitative (Fig. 1) and quantitative (Figs. 1–3) comparison of NI and SI ^{14}C datasets testify to a robust mid- to late 13th century settlement of NZ. While our analysis does not contradict previous estimates of human settlement in NZ, we demonstrate a measurable temporal difference between initial human contact in the NI and the SI. Dates on rats support early settlement in the north, and moa-hunting practices support a later shift to the SI.

Brown and Crema (22) also demonstrated that nationwide demographic models obscure regional variation. They used 334 TIA samples spanning circa 750 y grouped into 100-y intervals and divided the data into the horticultural north, a central horticultural region, and the suboptimal southern zone. They suggest a low population density in the northern horticultural area until AD 1450 to 1500, followed by a population plateau. This pattern matches the "logistic" settlement hypothesis proposed by Kirch (31) and Anderson (33), whereby the population in the north levels off when the landscape becomes densely packed, the productive and marginal regions are exhausted, and the carrying capacity is met. Their model for the nonhorticultural south suggests that the population rapidly grew and sharply declined as faunal resources diminished at ∼AD 1450 (19, 22). Using a much larger and diverse ^{14}C dataset, our analysis suggests a logistic population growth (up to AD 1400) for the overall NZ trend. It highlights differences in NI and SI population trends. Our models also show a shift in population circa 100 y earlier than previously suggested, which corresponds with regional climate trends, deforestation patterns, and changes in subsistence practices (Figs. 1 and 4).

The climate (temperature and precipitation patterns) for the eastern NI and western/southern SI is controlled by a complex interplay of the tropical (El-Niño-Southern Oscillation and Interdecadal Pacific Oscillation) and Antarctic (Southern Annular Mode [SAM]) wind circulation patterns, known as trough, blocking, and zonal conditions (32). Northerly to northeasterly airflows create blocking, southwesterly zonal, and southerly trough conditions, with variable climate patterns in the NI and SI (32). Speleothem records from the NI and high-resolution hydroclimate-proxy models of 25-y intervals from

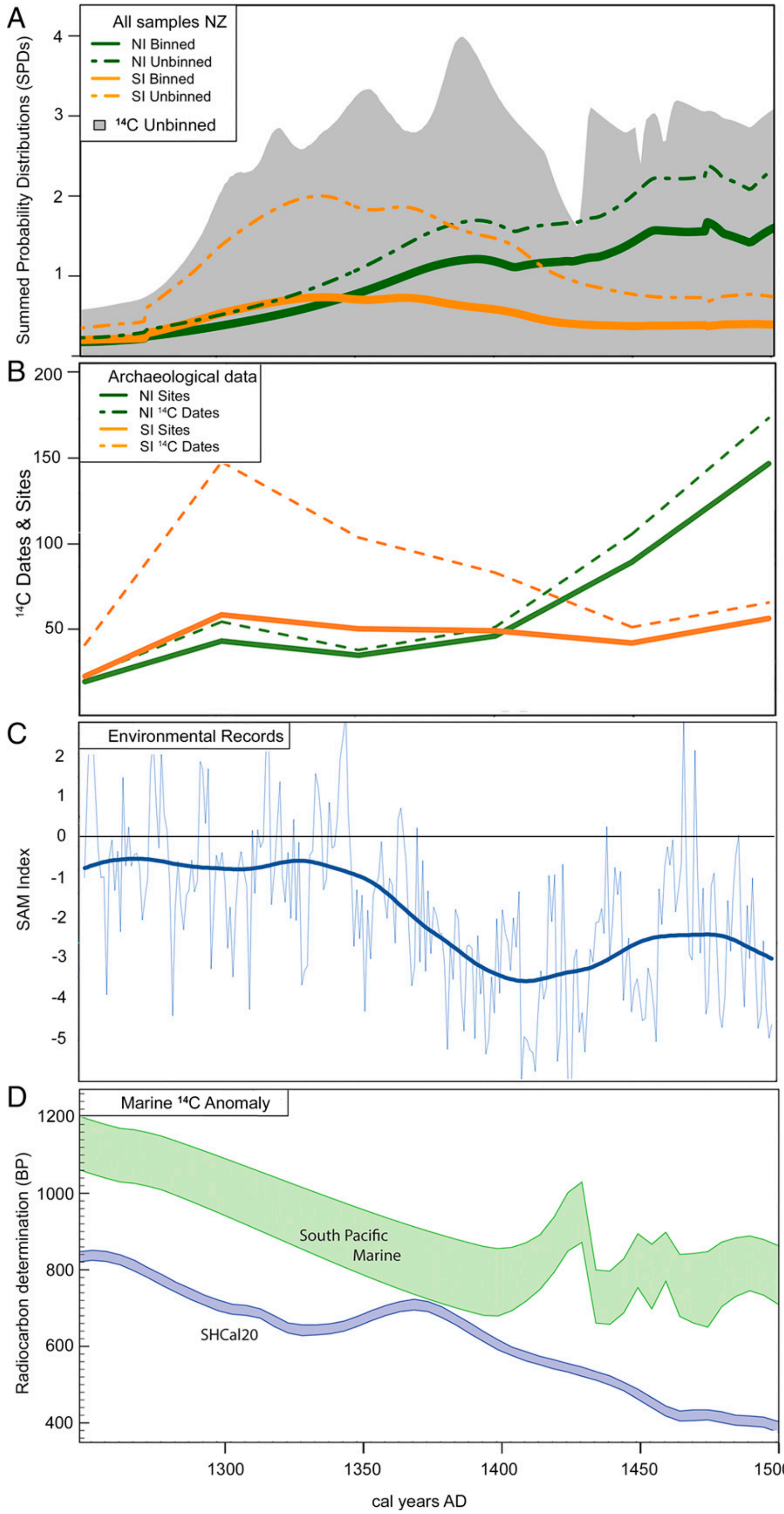

Fig. 2. Correlating archaeological (*A* and *B*) and environmental proxies (*C* and *D*) for AD 1250 to 1500. (*A*) SPDs of the NI and SI as a proxy for past population trends. Gray-shaded areas indicate calibrated unbinned radiocarbon (^{14}C) dates. Solid lines represent ^{14}C dates grouped into 50-y bins. Population continuously increases in the NI but levels off at AD 1340 and declines in the SI between AD 1380 and 1420. (*B*) Archaeological site counts and ^{14}C data frequencies in 50-y intervals. Early archaeological contexts in the SI have been oversampled (*A* and *B*). (*C*) Antarctic SAM reconstruction index as annual moving average (thin blue line) and 70-y loess filter (thick blue line), relative to AD 1961 to 1990 mean (black line) (30). Trough conditions are associated with negative SAM trends and indicate the onset of the LIA between AD 1385 and 1435. (*D*) Marine ^{14}C anomalies, as recorded in the South Pacific marine calibration curve, occurred between AD 1350 and 1400 (7).

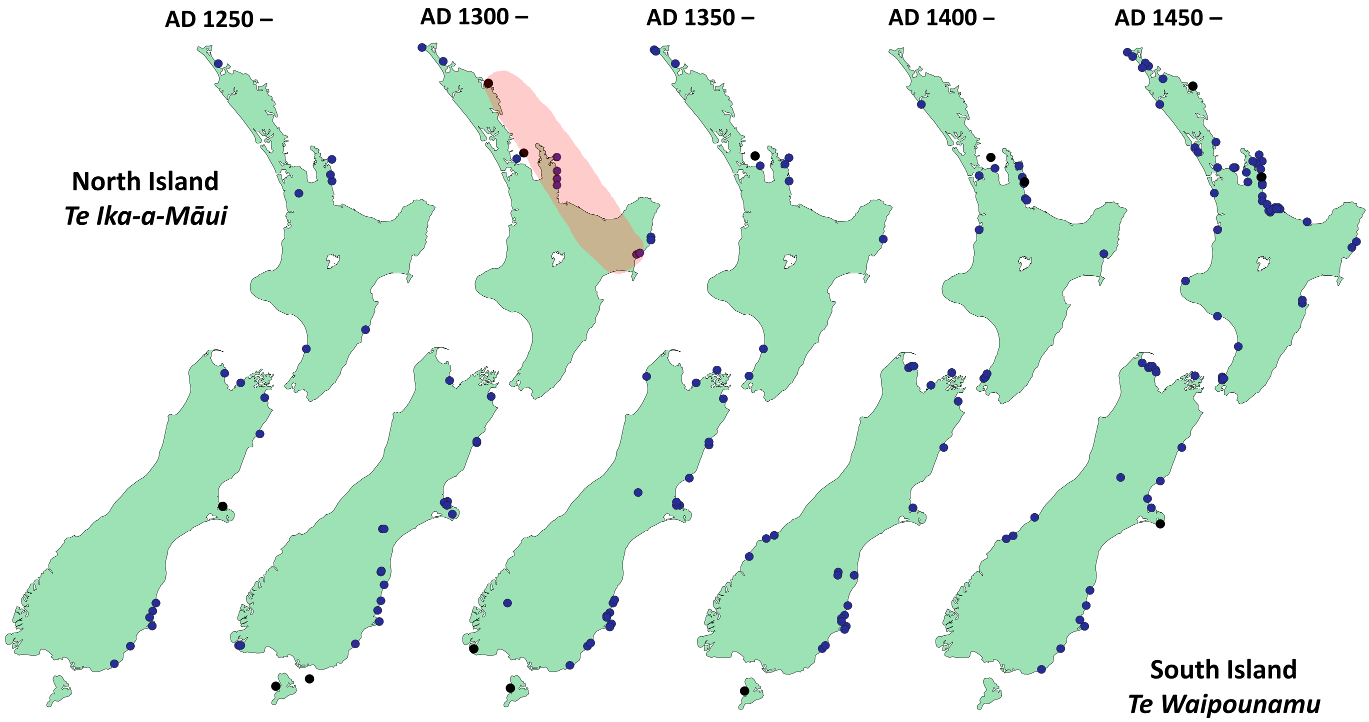

Fig. 3. The spatiotemporal distribution of human activities across NZ in 50-y intervals. Human activities are based on TSL and MS ^{14}C dates from archaeological sites. Red ellipse is the distribution of the Kaharoa tephra at AD 1314 ± 6 y (13). The eastern NI volcanic eruption had little impact on the population, which had dispersed to the SI by this time.

the SI suggest that strong zonal airflows initiated dry and cool weather conditions in the NI (AD 1250 to 1350) and wet and mild conditions in the SI (AD 1260 to 1360) (8, 9, 33). These sources indicate that climatic conditions were conducive to voyaging from the southern Cook Islands and southern Austral Islands to the NI of NZ and from Tonga/Fiji to the SI up until ~AD 1260, with return voyaging into central East Polynesia possible at multiple times between AD 1250 until the early 1600s (34) (Fig. 4).

The period after AD 1350 was less favorable for early settlers. Blocking regimes with high precipitation rates dominated in the NI between AD 1350 and 1500 and coincided both with "near-normal" temperatures (before AD 1450) and cooler temperatures (after AD 1450) (8). In the SI, Māori faced dry and mild blocking conditions during AD 1360 and 1385 and wet and cold trough conditions between AD 1385 and 1435 (Fig. 4) (9). Unsettled trough conditions coincide with negative phase SAM (30), which have been associated with the LIA (Figs. 2*C* and 4). Such trends are consistent with the coldest LIA temperatures in the Northern Hemisphere between AD 1400 and 1700 (6). Using "paired" (i.e., from the same context) terrestrial/marine dates, Petchey and Schmid (7) also identified an extreme oceanic event between AD 1350 and 1400 (Figs. 2*D* and 4). This shift in the marine ^{14}C signal broadly corresponds with the beginning of the LIA, while the brief return of the marine ^{14}C signal to normal matches a period of settled weather from AD 1400 to 1450 in the NI. It seems likely, therefore, that cooler seasonal temperatures in the SI associated with the LIA significantly affected the Māori economy (see, for example, ref. 38).

A recent analysis of terrestrial and marine ^{14}C ages modeled with the South Pacific curve point to kūmara (sweet potato) horticulture gardens across the NI coast at AD 1250 to 1300 and in the SI at AD 1290 to 1390 (37) (Fig. 4). The spread of kūmara horticulture coincided with widespread landscape burning. The land was most likely cleared for horticulture practices between AD 1280 and AD 1450 in the SI and continued for approximately 3 decades after moa hunting diminished (35, 36). In the NI, where forests are more resilient to burning, Newnham et al. (36) describe a two-step pattern with an initial phase of forest clearance starting just before the Kaharoa tephra deposit, followed by more extensive inland deforestation at ~AD 1400 to 1450. The latter is synchronous with expanding horticulture practices inland at AD 1390 to 1450 (37), a brief period of finer weather in the NI, and the expiration of moa as a primary food resource in the SI. Both the onset of the LIA in the SI at AD 1385 to 1435 and the reduction in moa subsistence AD 1400 to 1420 must have pushed communities to their economic limits, resulting in increased mobility to the economically more stable NI. The similarity in dates related to forest burning and the expansion of inland horticulture coincides with an increased settlement of the NI and endogenous population growth.

Our analysis highlights a complex model of early settlement in NZ. While this complexity has previously been assumed, we now can demonstrate the rate and scale of population changes. Future investigations should focus on how seasonal temperature and precipitation patterns affect horticulture and trade networks and how resource availability (or the lack thereof) influences supraregional demographic patterns. Essential to this is the refinement of chronologies for NZ's neighboring islands in the South Pacific to investigate the connectivity (39). Research into the marine ^{14}C reservoir (7, 40, 41), in particular, would help refine chronologies further and establish relationships between environmental adaptation, socioeconomic developments, and material culture changes in East Polynesia.

Materials and Methods

The Dataset. We collated 2,254 previously published ^{14}C ages from 712 archaeological sites across NZ. We applied a data quality assessment using the most parsimonious exclusions of ^{14}C ages in chronological models to maximize

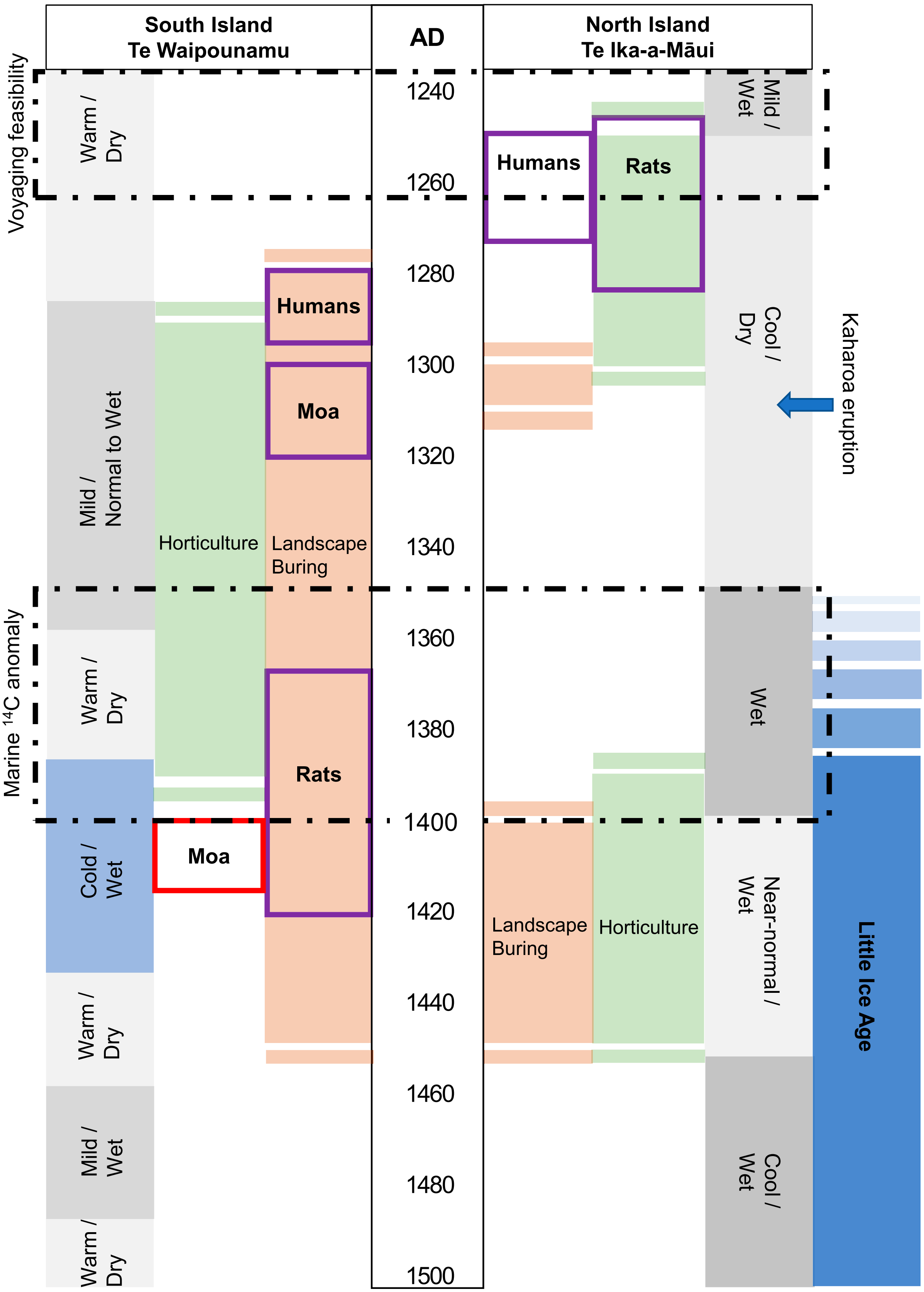

Fig. 4. Timeline of synchronous archaeological, demographic, and climatic trends. HPDs (purple boxes) of human settlement in the NI (AD 1250 to 1275) and SI (AD 1280 to 1295), the spread of rats in the NI (AD 1245 to 1280) and SI (AD 1365 to 1420), and the start of moa hunting in the SI (AD 1300 to 1320). The decline of moa hunting (red box) in the SI (AD 1400 to 1415). Correlation of HPDs with previously determined trends, including a period of voyaging to NZ until circa AD 1260 (34); deforestation in the NI (before AD 1312 and AD 1400 to 1450) and the SI (AD 1280 to 1450) (35, 36); horticulture practices in the NI (AD 1250 to 1300 and 1390 to 1450), and in the SI (AD 1390 to 1450) (37); Kaharoa tephra fall dated to AD 1314 ± 6 y (13); the onset of the LIA in the SI at AD 1385 to 1435; and climate trends in the NI (8, 9).

sample numbers (25, 28). We rejected 696 samples as outliers (*SI Appendix*, Fig. S1 and Table S1): class 1 samples are from questionable archaeological contexts ($n = 92$); class 2 samples are from disturbed contexts (n =13); class 3 samples have been identified as affected by laboratory contamination ($n = 63$); class 4 samples cannot be calibrated for various reasons ($n = 83$); class 5 samples have known pretreatment issues ($n = 138$); class 6 samples are unreliable marine materials ($n = 103$); class 7 are unreliable terrestrial samples ($n = 180$); and class 8 samples are extreme outliers ($n = 24$). The *SI Appendix* provides information on the rejection of individual samples. We used the remaining 1,558 ^{14}C ages and divided them into three groups: TSL, MS, and TIA (Dataset S1). Most dates are from the SI and NI of NZ, while a small percentage are from surrounding islands.

Establishing the Timing of Settlement. Initially, we separated the ^{14}C ages into three temporal groups to test the outcome of different minimum cutoff dates (i.e., 300/400/475 BP for terrestrial samples; *SI Appendix*, Table S2*A*). We used temporal parameters of 1,000 and 475 BP (AD 950 to 1475). Wiggles in the terrestrial calibration curve at ∼400 BP complicate the modeling by producing multimodal distributions (*SI Appendix*, Fig. S2). Therefore, we selected samples with a date older than 475 BP for terrestrial dates and 885 BP for marine dates. This ensures that the bounding dates fall on a steep part of the calibration curves, avoiding areas of multiple wiggles.

Bayesian Analysis. We modeled HPDs in the OxCal program version 4.4 (26) and calibrated all of the terrestrial dates using the SHCal^{13} (42) and SHCal^{20} calibration curves (43). We compared results with calibrated marine samples using both the South Pacific curve (7) and the Marine^{13} curve with a regional marine ^{14}C reservoir offset (ΔR value) of -7 ± 45 ^{14}C years (44) and the Marine^{20} curve (45) with a regional ΔR value of -154 ± 38 ^{14}C (7) (*SI Appendix*, Table S2*B*). We used the program OxCalparser to build robust Bayesian models in OxCal (28). We constructed Bayesian models based on top-down approaches to represent human activities by evaluating ^{14}C ages as a single entity using uniform single-phase models for unordered groups (25). The general t-type outlier model was used to model TSL and MS ^{14}C dates, and the charcoal plus outlier model (46), which accounts for inbuilt ages in charcoal samples, was used for TIA samples. We generated HPDs from different materials across different geographic regions (SI versus NI) and economic divisions (*SI Appendix*, Table S2*C*). We then compared HPDs using the "Difference" function to find the probability distributions for the difference between two parameters (*SI Appendix*, Table S3). We ran each model multiple times, and modeled ages were rounded to the nearest 5 y to avoid spurious precision (47). Unless stated, we present HPDs at the 68% confidence level in italics. Dataset S2 provides all of the Bayesian codes used in the paper and *SI Appendix*.

Frequency Analysis. We generated several quantitative analyses of SPDs using rcarbon, an extension package for R (48). Several biases involved in SPDs have been previously identified (49); these include different sampling intensities of ^{14}C dates within regions and periods, the effects of terrestrial and marine calibration curves on the shape of the distribution of ^{14}C dates, and taphonomic site loss. We minimized biases in SPD plots by (1) screening data for quality and systematically filtering out unreliable data (*SI Appendix*); (2) using ^{14}C dates directly associated with human settlement activities; (3) aggregating the median value of calibrated ^{14}C dates within 50-y bins to avoid oversampling archaeological contexts and to facilitate the comparison with other archaeological proxies; (4) presenting smoothed and unnormalized distributions of summed ^{14}C dates to avoid artificial peaks in the SPDs at points where the ^{14}C calibration curve is steep (50); (5) constructing several models based on different material classes (TSL, MS, and TIA), calibration curves, and regions (NI and SI) (*SI Appendix*, Fig. S3 *A–H*); (6) modeling traditional archaeological proxies including the raw counts of archaeological sites and observed ^{14}C dates in 50-y intervals (*SI Appendix*, Table S4), and (7) mapping the spatiotemporal distribution of TSL and MS samples in 50-y intervals. We compared all of the models against published critical thresholds, particularly environmental turning points (the Kaharoa tephra, the LIA, and voyaging feasibilities) and human behavior (deforestation and changes in subsistence). Dataset S3 provides the code used, written in the R statistical computing language. Data from the South Pacific curve can be extracted here (7, 40, 41).

Data, Materials, and Software Availability. All of the study data are included in the article and/or supporting information.

ACKNOWLEDGMENTS. We thank Atholl Anderson and three anonymous researchers for reading earlier versions of this manuscript. We also thank Enrico Crema for valuable comments on uploading the South Pacific curve on R and Michael Dee for providing the Charcoal Plus Outlier model. The paper was written while M.M.E.B. was funded by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) under Germany's Excellence Strategy – EXC 2150 – 390870439 and by the Australian Research Council through a Centre of Excellence grant (CE170100015). Funding for the publication of this paper was provided by a University of Waikato Marsden Support Grant to F.P.

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